Environmental regulation and horizontal mergers in the eco-industry

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Abstract

This paper considers the environmental policy and welfare implications of a merger between environment firms (i.e., firms managing environmental resources or supplying pollution abatement goods and services). The traditional analysis of mergers in Cournot oligopolies is extended in two ways. First, we show how environmental policy affects the incentives of environment firms to merge. Second, we stress that mergers in the eco-industry impact welfare beyond what is observed in other sectors, due to an extra effect on pollution abatement efforts; this might lead to disagreements between an anti-trust agency seeking to limit market concentration which can be detrimental to consumer surplus and a benevolent regulator who maximizes total welfare.

Keywords: Eco-industry, environmental policy, horizontal mergers

JEL Classification: D62, H23, L11

1 Introduction

Over the past decades, the provision of goods and services to abate pollution or manage environmental resources has by and large become the core business of specialized private firms. This so-called eco-industry is now approaching the aerospace and pharmaceutical sectors in size, with an estimated 2005 global market of US $653 billion that is expected to reach US $776 billion by 2010.[1] Unsurprisingly, government agencies and policy makers are paying extra attention to

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[1] These figures are from Environmental Business International (2006), a private firm which has been collecting and publishing data on the environment industry since 1988.

this sector: not only does it account for a significant number of jobs (1.5 million jobs, or 3.8% of total employment, in the European Union alone in 2002, according to **?**), it also constitutes a key ingredient of industrial competitiveness, trade advantage and social stability in a world where the pressure to protect environmental resources is mounting.

Acknowledging this development, the economic literature has lately re-examined optimal environmental policies in the presence of an eco-industry, assuming the economy is either closed (David & Sinclair-Desgagné 2005, Nimubona & Sinclair-Desgagné 2005, Requate 2005, Canton et al. 2005) or open (Fees & Muehlheusser 2002, Copeland 2005, Canton 2006). These articles, however, did not study how environmental regulation affects concentration and mergers in the eco-industry. Investigating such aspects of industry structure seems nevertheless crucial for an understanding of the supply of environmental resources and abatement technologies. In a first attempt to do so, **?** just took into account endogenous entry and exit by environment firms in establishing optimal emission taxes. The present paper, on the other hand, will now consider the relationship between emission taxes and mergers of environment firms.

Mergers and acquisitions are quite frequent in the eco-industry. The main firms in the U.S. waste management market, for instance, namely Waste Management Inc., Allied Waste Inc. and Republic Services, secured their growth throughout the 1980s and 1990s via mergers and acquisitions. In the air pollution abatement segment, BASF Catalyst, a division of the German chemical manufacturer BASF, announced in May 2006 it had finally got hold of its U.S. competitor Engelhard, in a hostile takeover that ended up costing more than US $5 billions; this acquisition constitutes BASF's largest such transaction in its 140-year history. In water treatment, Idaho-based Blue Water Technologies Inc. announced in September 2006 it had acquired Applied Process Technology Inc., a Texan filter producer. These cases, and many others, seem to corroborate a trend reported earlier by the World Trade Organization (WTO, 1998):

"The available evidence suggests that there is a tendency towards increasing concentration in the environmental industry. A study on mergers and acquisitions in the US in the environmental industry suggests that scale benefits and consumer preferences favour large firms which tend to achieve higher returns than their smaller rivals (European Commission, 1994). [...] As a result of these developments, the number of mergers and acquisitions increased between 1987 and 1991 at an annual rate of 56 per cent to reach 223 transactions in 1991."

Horizontal mergers have of course been a matter of public policy concern for some time already (see the Clayton Act, 1914 and the Treaty of Rome, Article 81(1), 1957). To inform antitrust authorities, one early branch of the literature looked at the welfare implications of mergers (**?**, Farrell & Shapiro 1990). On the one hand, mergers may generate scale economies and deliver efficiency gains; on the other hand, they can reduce industry competition and induce losses in consumer surplus. Public authorities will then have to trade-off these positive and

negative effects in deciding to approve a merger or not.

Another stream of literature would rather analyze incentives for firms to merge, by comparing profits before and after a merger. Under linear demand and cost functions, Salant et al. (1983) initially showed that the number of firms merging together must account for at least 80% of incumbent firms, in order to make a merger profitable. Extending this model, Fauli-Oller (1997) next emphasized the concavity of demand as the main determinant of profitability: the more concave the demand function, the less lucrative the merger. An important caveat of these analyses is that, with linear costs, firms remained identical after a merger to what they were beforehand. Perry & Porter (1985) first relaxed the linear-cost assumption, thereby introducing synergies through the amount of the industry's total capital stock possessed by incumbent firms - the larger a firm's share of capital, the lower its production costs. Based on this approach, McAfee & Williams (1992) returned to the welfare implications of horizontal mergers, showing that current Mergers Guidelines might at the same time authorize some welfare-reducing mergers and forbid some profitable welfare-enhancing ones.

The merger literature was recently specialized to investigate the relationship between environmental regulation and incentives to merge (Hennessy & Roosen 2002, **?**). Current work deals with polluting sectors, however, not the eco-industry. The latter, to be sure, raises a number of specific issues. First, while incentives to merge are of course also influenced by environmental policy, the relationship holds in a different way: as first pointed out by David and Sinclair-Desgagné (2005), environmental policy affects both the size *and* elasticity of *demand* for environmental goods and services, hence the market power and potential spillovers resulting from a merger. Second, the welfare implications of a given merger go beyond consumer surplus and firm profit. Such a merger influences the supply of environmental goods and services, which then impinges on the quality of the environment; the traditional trade-off between lower production costs and consumer surplus reduction must therefore be properly extended.

This paper's raison d'être is then to consider horizontal mergers in the eco-industry, dealing with the above specificities in a Perry & Porter (1985) and McAfee & Williams (1992) framework where such mergers also entail reductions in production cost. We shall show first that the minimal size for a profitable merger increases with the stringency of environmental regulation; in other words, mergers are less likely to occur as environmental policy tightens up. This result seems empirically testable. It implies, moreover, that putting stronger requirements on polluters might not lower competition in the eco-industry and exacerbate consequently the market power of environment firms. We shall also stress that, since mergers in the eco-industry impact welfare beyond what is observed in other sectors due to their effect on abatement efforts, some disagreements might arise between an anti-trust agency seeking to limit the impact of market concentration on consumer surplus and a benevolent regulator who wants to maximize total welfare.

The paper unfolds as follows. The following section presents our model. Section 3 shows that a higher tax on polluting emissions reduces incentives to merge in the eco-industry. Section 4 explores next the conditions under which a merger in the eco-industry is welfare enhancing. Section 6 contains concluding remarks.

2 The basic model

Consider a representative price-taking polluting firm that produces one consumption good and sells it on a competitive market at unit price P.[2] The marginal production cost for this good is assumed to be constant and is referred to as c. For an output level x, the firm generates polluting emissions $e(x, A)$, where A represents the firm's abatement effort. Without loss of generality, we take the emission function to be $e(x, A) = \frac{1}{2}(x - A)^2$. This means that $e_x(x, A) > 0$ (more production entails more pollution), $e_A(x, A) < 0$ (more abatement decreases total emissions), $e_{xx}(x, A) > 0$ (emissions from the last unit produced increase with the production level), and $e_{AA}(x, A) > 0$ (abatement effort is subject to diseconomies of scale). Last, we have $e_{xA}(x, A) < 0$ (the higher the abatement, the less the last unit produced generates pollution).[3]

The representative polluting firm is subject to a constant tax t per-unit of emission. However, it can purchase abatement goods and services from a specialized environment industry at a unit price p. It then sets production and abatement efforts in order to maximize the following profits:

$$\max_{x,A} \varphi = Px - cx - pA - te(x, A) \ . \tag{1}$$

Normalizing final consumers' demand as $P(x) = 1 - x$, basic calculations yield the following optimal levels of production and abatement for the polluting firm:

$$x = 1 - c - p \tag{2}$$

$$A = 1 - c - \frac{1 + t}{t} p \ . \tag{3}$$

Let $p(A)$ denote the inverse demand function faced by the environment firms. It is given by the polluters' decision to abate, as captured by equation (3). Rearranging this equation, the inverse demand is then $p(A) = \alpha_1 - \alpha_2 A$, where $\alpha_1 = \frac{(1-c)t}{1+t}$ and $\alpha_2 = \frac{t}{1+t}$. Note that both coefficients - the intercept and the slope - are increasing in t, the environmental tax.

The eco-industry is initially composed of n identical firms competing à la Cournot. Following McAfee & Williams (1992), the total cost of an environment firm i is assumed to be equal to $\frac{a_i^2}{2k_i}$,

[2] One could consider an oligopolistic polluting industry without modifying our main results, as long as this industry acts as a price-taker on the market for abatement goods and services.

[3] Compared to David & Sinclair-Desgagné (2005), Nimubona & Sinclair-Desgagné (2005) and Canton et al. (2005), we do not assume that the emission function is additively separable.

where a_i is the firm's output and k_i its capital investment. Firms are identical and $\sum_{i=1}^{n} k_i = K$. Each firm thus holds an equal share $k_i = k = \frac{K}{n}$ of the industry's global capital. Define

$$\beta_i = \frac{\alpha_2 k_i}{\alpha_2 k_i + 1}$$

and

$$B = \sum_{i=1}^{n} \beta_i \ .$$

One can check that the letter β_i indicates firm i's market share, whereas B renders the overall size of the market.[4]

The following equilibrium quantities and price are now derived for the pre-merger case where all firms are symmetric (see (McAfee & Williams 1992)).[5]

$$a = \frac{\alpha_1}{\alpha_2} \frac{\beta}{1+B}$$

$$A = \frac{\alpha_1}{\alpha_2} \frac{B}{1+B}$$

$$p = \frac{\alpha_1}{1+B} \quad .$$

An environment firm's profit is then

$$\pi = pa - \frac{a^2}{2k} \ . \tag{4}$$

3 Horizontal mergers

This section will now consider the incentives of environment firms to merge. The first part studies the minimal size of a profitable merger. The second part examines the impact of environmental policy.

3.1 On merger size and profitability

Suppose that s firms in the eco-industry decide to merge. The total capital of new entity is then sk. Indexing by s the equilibrium values for the merged firm and by o those for each of the $(n-s)$ remaining firms (the *outsiders*), we have

$$\beta_s = \frac{\alpha_2 sk}{\alpha_2 sk + 1}$$

[4] More precisely, the market share of a firm i is $s_i = \frac{\beta_i}{B}$.

[5] In this case, $k_i = k, \forall i$ and $\beta_i = \beta, \forall i$. Therefore $a_i = a, \forall i$.

$$\beta_o = \beta = \frac{\alpha_2 k}{\alpha_2 k + 1} \ .$$

In this case, B becomes $B_m = \beta_s + (n-s)\beta_o$, so

$$B_m = \frac{s(\alpha_2 k)^2(1+n-s) + n\alpha_2 k}{(s\alpha_2 k + 1)(\alpha_2 k + 1)}$$

and

$$a_s = \frac{\alpha_1}{\alpha_2}.\frac{\beta_s}{1+B_m}$$

$$a_o = \frac{\alpha_1}{\alpha_2}.\frac{\beta_o}{1+B_m} \ .$$

Total output is now

$$A_m = \frac{\alpha_1}{\alpha_2}.\frac{B_m}{1+B_m}$$

and the market price is given by

$$p_m = \frac{\alpha_1}{1+B_m} \ .$$

It can be seen that $B_m < B$ and $p_m > p$, so the size of the market is reduced and the price for abatement is increased with the merger. Moreover, $a_o > a$ and $a_s < a$, meaning that outsiders increase their output and insiders decrease theirs with the merger.

A merger, however, is not always profitable for the involved firms. To be sure, there are two main reasons for firms to merge. First, this reduces production cost. Second, total output will shrink, which increases the market price and the firms' profit (Perry & Porter 1985, Fauli-Oller 2002). **?** and others have argued, on the other hand, that firms which do not participate in the merger may actually benefit more than those which merge. They expand output and profit from a higher market price, thereby free-riding on the merger's participants who in turn do not capture all the rent they generate. This may dissuade firms from merging.

Using the methodology of Allain & Souam (2004), one can show that an s-firms merger is profitable for the insiders only if s is superior to a threshold $\hat{s}$ (i.e. if the number of insiders is sufficient high relative to the number of outsiders). The profit of the merged firm is equal to $\pi_s = p_m a_s - \frac{a_s^2}{2sk}$. Compare now the profit of the merged entity with s times the ex ante individual profit given by equation (4). It can be shown that the sign of the difference is the same as the sign of the following expression:

$$\begin{aligned} g(s,n,\alpha_2) \quad = \quad & (\alpha_2 k+1)^2(2s\alpha_2 k+1)[1+(n+1)\alpha_2 k]^2 \\ & -(2\alpha_2 k+1)[s(\alpha_2 k)^2(2+n-s)+\alpha_2 k(n+s+1)+1]^2 \end{aligned} \tag{5}$$

This expression is negative when s is inferior to a unique threshold $\hat{s}$, and positive otherwise. This constitutes our first result.

Lemma 1 *There exists a unique threshold on the number of insiders (s) from which a merger in the eco-industry becomes profit-enhancing.*

A proof of the existence and unicity of this threshold is available upon request.

3.2 The impact of environmental policy

Let us now examine how a change in environmental policy can affect incentives to merge in the eco-industry.

Clearly, the level of the emission tax t influences the polluters' abatement decisions and the ensuing inverse demand function $p(A) = \alpha_1 - \alpha_2 A$, where $\alpha_1 = \frac{(1-c)t}{1+t}$ and $\alpha_2 = \frac{t}{1+t}$. Note that a more stringent tax not only increases the market for abatement by raising the intercept α_1; it also modifies the price-elasticity of demand for abatement goods and services by augmenting α_2. The parameter α_1, however, does not appear in $g(s, n, \alpha_2)$. The impact of a change in environmental taxation on merger profitability occurs thus only through the slope coefficient α_2.

To fix ideas, let us first look at the case of a two-firm merger. Such a merger enhances profits if and only if

$$g(2, n, \alpha 2) > 0 \ , \tag{6}$$

where

$$g(2, n, \alpha_2) = 1 - 2(n-5)\alpha_2 k + [17 + (2-3n)n](\alpha_2 k)^2 + 4[1 - (n-2)n](\alpha_2 k)^3 \ .$$

Plotting this function, we can show that, as α_2 grows across the interval $[0, 1]$, $g(2, n, \alpha_2)$ ends up taking negative values. Hence, as the emission tax t increases (so α_2 goes up as well), the two-firm merger tends to become unprofitable. In other words, raising the emission tax reduces incentives to form such a merger.

Turning to the general case of an s-firm merger, we found that a similar conclusion held (qualitatively) in numerous simulations: namely, a rise in the emission tax t (so in α_2) makes mergers of a given size less profitable.[6] The threshold $\hat{s}$, moreover, tends to go up with t. This supports our first Proposition.

Proposition 1 *When $n > 2$, making the emission tax more stringent raises the minimal size $\hat{s}$ at which a merger becomes profitable.*[7]

The intuition behind this result is the following. As explained before, incentives to merge come from the opportunity to reduce costs while lowering output and increasing prices. Outsiders,

[6] Such simulations were carried out for $n \in [2, 10^{10}]$ and $K \in [0.01, 10^{10}]$.

[7] Were the eco-industry a duopoly ($n = 2$), $g(2, 2, \alpha_2)$ would always be positive, as the two firms would naturally prefer to merge to form a monopoly. This comes from the absence in this case of free-riding outsiders.

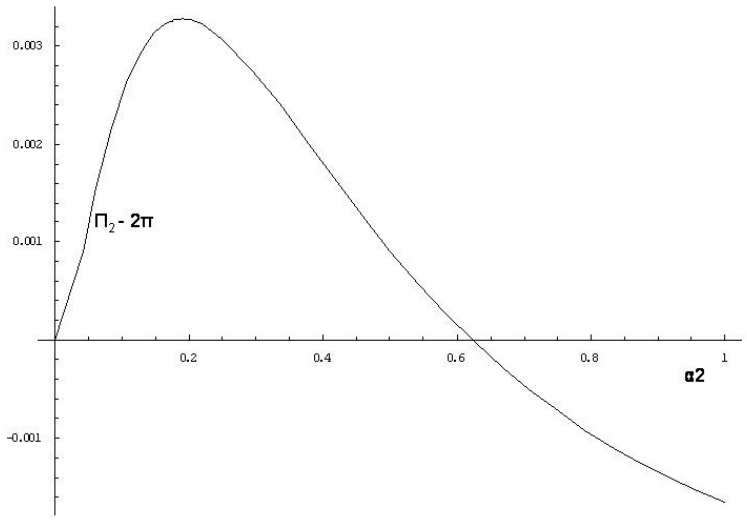

Figure 1: The impact of a change in the environmental policy on a two-firms merger profitability ($n > 2$)

however, will free-ride on the latter, thereby deterring smaller mergers. In the present context, a bigger emission tax will amplify such free-riding, as it makes demand for abatement less price-elastic and allows therefore a given merger to further raise prices.

This proposition refines the well-known observation that incentives to merge decrease as B - the size of the market - increases (Fauli-Oller 2002), or equivalently that horizontal mergers generally happen in declining industries (**?**).[8] In the American waste management market, for instance, the main U.S. firms seem indeed to have secured their growth through mergers and acquisitions when the market was stable (**?**, **?**). Our explanation, however, emphasizes the impact of environmental regulation on the price-elasticity rather than on the size of demand for abatement goods and services.

Let us now investigate the welfare implications of horizontal mergers in the eco-industry.

4 A welfare analysis

Social welfare is defined as the sum of the final consumers' surplus (CS), the polluting industry's profit (φ) and the eco-industry's total profits ($\Pi = \sum_{i=1}^{n} \pi_i$), minus the social damage caused by pollution. Denote as ν the harm inflicted per unit of emission, and by E total pollution damages. Formally,

$$CS = \int_0^x P(u)du - Px$$

$$\varphi = Px - cx - pA - te(x, A)$$

$$\Pi = \sum_{i=1}^{n} (pa_i - \frac{a_i^2}{2k_i}) = pA - \sum_{i=1}^{n} \frac{a_i^2}{2k_i}$$

$$E = \nu e(x, A) \ .$$

As in **?**, let tax revenues be redistributed in a neutral way. We shall now examine separately the consequences of a merger on each of these functions.

4.1 The eco-industry's profits

Participants to a merger always increase their profits, for they would otherwise choose to remain apart and the merger would not occur. Outsiders are also winners, since their per unit production costs remain unchanged while they can sell at a higher price. Hence, the eco-industry's total profits always goes up after some environment firms merge.

[8] Note that $B = \frac{n\alpha_2 k}{\alpha_2 k+1}$ before any merger occurs, which is increasing in α_2.

4.2 Pollution damages

Given the polluting firm's optimal production and abatement levels $x = 1 - c - p$ and $A = 1 - c - \frac{1+t}{t}p$, polluting emissions are equal to

$$e(x, A) = \frac{1}{2}(x - A)^2 = \frac{1}{2}(\frac{p}{t})^2 \ . \tag{7}$$

The higher the price p for pollution abatement goods and services, the higher the emission level. Conversely, the higher the tax t, the lower the emissions.

Following a merger in the eco-industry, we have that $p_m > p$, so the price of abatement increases. All things equal, such a merger then induces less abatement effort and favors further depletion of environmental resources.

Consider now the net difference between post-merger and pre-merger pollution damages, which is given by

$$\Delta E = \nu(\frac{p_m^2 - p^2}{2t^2}) \ . \tag{8}$$

When t increases, the denominator in (8) grows, which tends to lessen the pollution induced by a merger of environment firms. On the other hand, t also affects the numerator in (8) in a way which is described in the following Lemma.[9]

Lemma 2 *(i) The higher t (resp. n), the higher (resp. lower) the initial abatement price p. (ii) The higher the initial price, the higher the difference between post and pre-merger prices.*

It follows that a higher tax augments the numerator in (8). Setting a larger emission tax thus has an ambiguous effect on the variation in pollution after some environment firms merge.

According to our simulations, a higher tax (particularly at already low taxation levels) might actually bring about a higher variation in environmental quality after a merger occurs. This fact and its rationale constitute the next proposition.

Proposition 2 *Variation in pollution damages following a horizontal merger in the eco-industry are magnified under higher emission taxes, when the indirect negative impact of a merger on environmental quality — through the difference between post and pre-merger abatement prices — exceeds the direct positive impact of the tax.*

Note that an increase in the number of environment firms n will alleviate this problem by reducing the gap between p_m and p (see Lemma 2).[10]

[9] Proof available upon request.

[10] According to the previous section, moreover, higher emission taxes tend to deter merging activities per se. The overall effect on pollution of imposing more stringent emission taxes is therefore difficult to characterize in general.

4.3 Polluters' profits

The overall effect of a merger on polluters' profits seems ambiguous. Recall that the representative polluter's profit is $\varphi = Px - cx - pA - te(x, A)$. The price P of the final good being positively correlated with the price for abatement (since $P = c + p$), it thus increases after some environment firms merge. Under those circumstances, polluters also produce less, which lowers total production costs. The variation of pA, on the other hand, is unclear, since p increases but A goes down. Moreover, polluting emissions are higher after a merger, so the tax payment is increased.

Let us now substitute the optimal levels of output and abatement effort by polluting firms ($x = 1 - c - p$ and $A = 1 - c - \frac{1+t}{t}p$) in their profit function. The difference between post- and pre-merger polluters' profits is then equal to

$$\Delta\varphi = \frac{p_m^2 - p^2}{2t} > 0 \ . \tag{9}$$

In the present model, a horizontal merger in the eco-industry therefore increases polluters' profits. This (perhaps surprising) result comes from the fact that the higher equilibrium price P more than compensates for higher abatement costs and tax payment.

4.4 Consumer surplus

Following a merger in the eco-industry, polluting firms produce less and the price of the final good increases. Consumer surplus then shrinks.

To see more precisely what happens, use the equilibrium levels of P and x to write the difference between post- and pre-merger consumer surplus as

$$\Delta CS = (1 + c)(p - p_m) \ . \tag{10}$$

This entity is necessarily negative, since $p_m > p$. As the environmental tax increases, the gap between p_m and p grows bigger so the incurred loss worsens. From the previous section, however, we know this impact is reduced when there are more competing environment firms or the price of abatement goods and services is low.

4.5 Total welfare

In sum, a merger of environment firms has opposite effects on welfare: it decreases environmental quality and consumer surplus but increases the eco-industry and the polluting sector's profits.

To examine the overall outcome, note that total welfare is given by

$$W = \int_0^x P(u)du - cx - \sum_{i=1}^{n} \frac{a_i^2}{2k_i} - \nu e(x, A) \ . \tag{11}$$

At the equilibrium levels of x and A, the latter transforms into

$$W = 1/2 - \frac{c(2-c)}{2} - \frac{\alpha_1^2}{2(1+B)^2}[1 + \frac{B}{t}(1+t)(1-B.h) + \frac{\nu}{t^2}] \ , \tag{12}$$

where $h = \sum_{i=1}^{n}(\frac{a_i}{A})^2 = \sum_{i=1}^{n}(\frac{\beta_i}{B})^2$ is the Herfindahl index of the eco-industry.[11] Only the last term of the latter expression is modified by the occurrence of a merger. Hence, a horizontal merger in the eco-industry is welfare-enhancing if and only if

$$\frac{\alpha_1^2}{2(1+B_m)^2}\left[1 + \frac{B_m}{t}(1+t)(1-B_m.h_m) + \frac{\nu}{t^2}\right] < \frac{\alpha_1^2}{2(1+B)^2}\left[1 + \frac{B}{t}(1+t)(1-B.h) + \frac{\nu}{t^2}\right],$$

where h_m is the eco-industry's Herfindhal index after the merger. Rearranging this inequality yields the following proposition.

Proposition 3 *A horizontal merger in the eco-industry is welfare-enhancing if and only if*

$$\frac{B(1-B.h)(1+B_m)^2 - B_m(1-B_m.h_m)(1+B)^2}{(1+B)^2 - (1+B_m)^2} > \frac{\nu + t^2}{t(1+t)} \ . \tag{13}$$

This result gives rise to several interesting interpretations. First, as ν increases, a merger in the eco-industry is less likely to be welfare-increasing (for the right-hand-side of (13) increases in ν). This is not surprising since such a merger induces less abatement efforts to curb emissions; were pollution inflicting more damage on society, having some environment firms merge would then be less desirable.

We have studied the impact on (13) of the number of environment firms n. This number affects only the left-hand-side of (13), where it has an ambiguous effect. First, a higher n reduces the negative consequences of a merger on the environment and on downstream users, while raising the potential cost economies one could get through a merger. On the other hand, when n increases for a given s, the proportion of insiders decreases, thereby reducing the cost economies this particular merger would yield.[12] No clear-cut conclusion therefore exists concerning the impact of an increase in n on condition (13). When $K = 1$, however, it can be shown that a larger n always makes a merger more likely to be welfare enhancing.

The emission tax t shows up on the right-hand-side of expression (13), which increases in t if

[11] The algebra that lead to this expression can be found in Appendix **??**.

[12] Recall that the outsiders' production costs always increase after a merger.

t is not too low. It is also implicit on the left-hand-side, through α_2 which enlarges B and B_m but diminishes h_m.[13] Overall, the effect of t on condition (13) is therefore uncertain.

Finally, note that the denominator of the left-hand-side of (13) is positive, since B_m is always smaller than B. The right-hand-side of (13) is also always positive. The following corollary is thus at hand.

Corollary 1 *A necessary condition for a merger to be welfare-enhancing is*

$$\frac{B(1-Bh)}{B_m(1-B_m h_m)} > \left(\frac{1+B}{1+B_m}\right)^2 . \tag{14}$$

This inequality means that total production costs in the eco-industry decrease with the merger.

Before any merger, firms are identical and the eco-industry's total production costs are

$$\eta = \frac{na^2}{2k} .$$

After s firms in the eco-industry have merged, on the other hand, the eco-industry's total costs become

$$\eta_m = \frac{a_s^2}{2sk} + (n-s)\frac{a_o^2}{2k} .$$

We can show that the sign of the difference $\eta_m - \eta$ between post-merger and pre-merger total costs is in fact given by the following polynomial

$$\psi = -(\alpha_2 k)^3[ns^2 - s(n^2+n-1) + (n+1)^2] - 2(\alpha_2 k)^2(s+2n+2) - \alpha_2 k(s+2n+5) - 2.$$

If the term $[ns^2 - s(n^2+n-1) + (n+1)^2])$ is positive, then the whole expression is necessarily negative (so total costs would be reduced with the merger). Otherwise, ψ may either be positive or negative. The following proposition finally covers the two cases.

Proposition 4 *There are circumstances when a merger may increase total production costs in the eco-industry. This only happens in an industry with at least five firms and when the number of merging firms (s) is small compared to the total number of incumbent firms (n).*

5 Conclusion

This paper investigated the rationale and welfare consequences of horizontal mergers in the eco-industry. We assumed that such a merger creates a new entity with lower production costs

[13] In our model, since pre-merger firms are symmetric, $h = 1/n$ so h does not depend on t.

(because of synergies between previously separate firms), while increasing concentration in the eco-industry and therefore raising the price of pollution abatement goods and services.

In terms of welfare, it appears that mergers involving environment firms are not desirable if the social cost of pollution is large. When pollution generates major damages, however, it is reasonable to expect that the regulator will adopt a more stringent environmental policy, putting for example higher taxes on polluting emissions. Section 3 established that such a measure actually hampers incentives to merge in the eco-industry (a merger would have to include a larger number of firms in order to raise these firms' profits). This key result seems empirically testable. Its underlying intuition runs as follows: a more stringent tax will decrease the price-elasticity of demand for environmental goods and services, thereby allowing outsiders to a merger to benefit even more from the larger residual demand.

Sections 4 also emphasized that environmental costs should supplement conventional welfare analyses of mergers when dealing with horizontal mergers in the eco-industry.

Some possible extensions of the present work might be worth mentioning at this point. Other (more realistic) market structures should certainly be considered, such as asymmetric oligopolies and oligopolies with a competitive fringe. It would also be instructive and useful, moreover, to study the optimal emission tax in this context; to be sure, the proposed policy would now have to internalize its effect on the structure of the eco-industry.

References

Allain, M.-L. and Souam, S. (2004), 'Concentration horizontale et relations verticales', *Cahier 2004-02 Ecole Polytechnique* .

Canton, J. (2006), 'Environmental taxation and international eco-industries', *Submitted to Annales d'Economie et Statistiques* . 2006.

Canton, J., Soubeyran, A. and Stahn, H. (2005), 'Environmental taxation and vertical cournot oligopolies: How eco-industries matter', *In revision for Environmental and Resource Economics* .

Copeland, B. R. (2005), 'Pollution policy and the market for abatement services', *Work in Progress: presented during the EAERE conference in Bremen* .

David, M. and Sinclair-Desgagné, B. (2005), 'Environmental regulation and the eco-industry', *Journal of Regulatory Economics* **28**(2), 141–155.

Farrell, J. and Shapiro, C. (1990), 'Horizontal mergers: an equilibrium analysis', *American Economic Review* **80**, 107–126.

Fauli-Oller, R. (1997), 'On merger profitability in a cournot setting', *Economics Letters* **54**, 75–79.

Fauli-Oller, R. (2002), 'Mergers between asymmetric firms: profitability and welfare', *The Manchester School* **70**, 77–87.

Fees, E. and Muehlheusser, G. (2002), 'Strategic environmental policy, clean technologies and the learning curve', *Environmental and Resource Economics* **23**, 149–166.

Hennessy, D. A. and Roosen, J. (2002), 'Stochastic pollution, permits, and merger incentives', *Journal of Environmental Economics and Management* **37**, 211–232.

McAfee, R. P. and Williams, M. A. (1992), 'Horizontal mergers and antitrust policy', *The Journal of Industrial Economics* **40**, 181–187.

Nimubona, A.-D. and Sinclair-Desgagné, B. (2005), 'The pigouvian tax rule in the presence of an eco-industry', *FEEM. Nota de lavoro* (57-2005).

Perry, M. and Porter, R. (1985), 'Oligopoly and the incentive for horizontal merger', *The American Economic Review* **75**, 219–227.

Requate, T. (2005), 'Timing and commitment of environmental policy, adoption of new technology, and repercussions on r&d', *Environmental and Resource Economics* **31**, 175–199.

Salant, S. W., Switzer, S. and Reynolds, R. J. (1983), 'Losses from horizontal merger: The effects of an exogneous change in industry structure on cournot-nash equilibrium', *The Quarterly Journal of Economics* **98**(2), 185–199.

Williamson, Oliver, E. (1968), 'Economies as an antitrust defense: welfare tradeoffs', *American Economic review* **58**, 18–36.